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# A FUEL INJECTOR AND A METHOD FOR MANUFACTURING IT

## ~~Background Information~~ Field of the Invention

The present invention relates to a fuel injector ~~according to species of Claims 1 and 3.~~

## Background Information No. 35 40 660 describes

5 ~~From German Patent 35 40 660 C2~~, an electromagnetically actuatable fuel injector is ~~known~~  
having a valve housing, which, over a segment, surrounds a fuel intake feed pipe and a valve  
seat support. The valve seat support has a valve seat surface, which cooperates with a valve-  
closure member that can be actuated by a valve needle, so as to form a sealing seat. For  
achieving a necessary fuel quantity apportioned in the open-valve state between the valve-  
closure member and the valve seat surface, a desirable valve lift is set by interposing a lift-  
adjustment disk in the axial direction between a limit-stop plate and an end face of the valve  
seat support. After the setting is accomplished, the valve housing and the valve seat support  
are joined to each other, in that an end segment of a cylindrical retaining segment of the valve  
housing is crimped over the valve seat support.

However, this design has the following disadvantages:

Since the crimping force occurring as a result of the crimping can only be approximately  
specified by the crimping process, in that the end segment of the cylindrical retaining  
20 segment of the valve housing is crimped over the valve seat support, the tension generated  
between the valve seat support and the valve housing cannot be specified. In addition, the  
crimping is achieved by a plastic deformation of the end segment of the cylindrical retaining  
segment of the valve housing, the deformation being subject to aging, as a result of which the  
joining strength deteriorates between the valve housing and the valve seat support.

## Published Patent Application No. 196 26 576 describes

25 ~~From German Patent 196 26 576 A1~~, a fuel injector is ~~known~~  
joined to the valve seat support, in an alternative manner with respect to the above solution,  
via a screw connection. However, this solution is significantly more expensive because the  
additional screw element must be introduced, requiring for this purpose that a suitable thread  
30 be cut in the valve housing. Furthermore, introducing and tightening the screw element, from

the production-technical point of view, is an expensive and time-consuming production step.

~~Advantages of the Invention~~

## Summary Of The Invention <sup>n</sup>

5 In contrast, the fuel injector according to the present invention ~~having the characterizing~~  
~~features of Claim 1 or of Claim 3~~ has the advantage that the axial tension between the valve  
housing and the valve seat support can be prespecified, and the manufacturing process of the  
connection can take place in simple and cost-effective production steps. In addition, the  
connection is age-resistant, thus increasing the service life of the fuel injector.

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~~As a result of the measures indicated in the Claims 2 and 4 through 8, advantageous~~  
~~refinements of the fuel injector indicated in Claim 1 or Claim 3 are possible.~~

In an advantageous manner, a notch is configured as a circumferential groove on a lateral  
surface of the valve seat support, providing high strength for the crimping connection. In  
addition, a cost-effective manufacturing process of the notch results.

Advantageously, between the spring element and the crimped valve housing a support ring is  
provided. As a result, a uniform transmission of force from the crimping connection to the  
spring element is assured, and also the spring element is protected from external influences.

In an advantageous way, the crimping connection has a plurality of crimping segments, which  
are arranged so as to be offset circumferentially with respect to each other with regard to a  
valve axis, and at which the valve housing is joined to the valve seat support in a crimped  
25 partial connection, leaving out the uncrimped segments. As a result, the production of the  
crimping connection can be further simplified.

In an advantageous manner, a lift-adjustment disk is provided between the valve housing and  
the valve seat support. Using the lift-adjustment disk, the lift of the valve needle can be set.

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The manufacturing method according to the present invention, ~~having the features of Claim 9~~  
~~or of Claim 10~~, has the advantage of being executable so as to be cost-effective and capable  
of being automated.

~~As a result of the measures indicated in the Claims 11 through 13, advantageous refinements of the method indicated in Claim 9 or 10 are possible.~~

It is advantageous that after introducing the spring element, a support ring is inserted into the interstitial space formed after they have been joined, between the valve seat support and the valve housing. As a result, the spring element can be deformed more simply and stressed more uniformly.

In an advantageous manner, the spring element is prestressed by the action of a tubular prestressing tool that is guided around the valve seat support. A significantly simplified production sequence results from using the prestressing tool.

It is advantageous that the axial insertion depth of the valve seat support into the valve housing is set by a lift-adjustment disk 4, adjusting the lift of the valve needle. As a result, any difference between the valve needle length of the valve needle and a setpoint length can be compensated for.

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Drawing

Exemplary embodiments of the present invention are depicted in simplified form in the drawing and are discussed in greater detail in the subsequent description. The following are the contents:

Figure 1 depicts an axial cutaway view of a first exemplary embodiment of a fuel injector according to the present invention;

Figure 2 depicts the cutaway portion II in Figure 1, before the production of the crimping connection;

Figure 3 depicts the cutaway portion II in Figure 1, after the production of the crimping connection;

Figure 4 depicts a partial axial cutaway view of the second exemplary embodiment of

the fuel injector according to the present invention before the production of the crimping connection;

Figure 5 depicts the exemplary embodiment presented in Figure 4, after the production of the crimping connection;

Figure 6 depicts a partial axial cutaway view of the third exemplary embodiment of a fuel injector according to the present invention, before the production of the crimping connection;

Figure 7 depicts the exemplary embodiment presented in Figure 6, after the production of the crimping connection; and

Figure 8 depicts a cutaway view along the line VIII-VIII in Figure 7.

#### Description of the Exemplary Embodiments

Figure 1, in a partial axial cutaway representation, shows a fuel injector 100. Fuel injector 100 is designed here as a fuel injector 100 that opens to the inside. Fuel injector 100 functions in particular for the direct injection of fuel, in particular of gasoline, into a combustion chamber of a mixture-compressing internal combustion engine having externally supplied ignition, as a so-called fuel injector. However, fuel injector 100 according to the present invention is also suitable for other application cases.

Fuel injector 100 has a tubular connecting piece in the form of a valve seat support 1 having a spray-discharge opening 2. Spray-discharge opening 2, introduced into a cylinder head of the internal combustion engine, is sealed to the outside by a sealing ring 3. In place of a valve seat support 1, other connecting pieces, partially forming the housing of the valve, are conceivable, which in accordance with the invention are permanently joined to a valve housing 20 by crimping.

Valve seat support 1 has an axial longitudinal bore hole 4, which receives an axially movable valve needle 5. On valve seat support 1, a valve seat surface 6 is formed, which cooperates

with a truncated-cone-shaped, downstream-tapering valve-closure member 7 of valve needle 5, creating a sealing seat. In the depicted exemplary embodiment, valve-closure member 7 is formed as one piece with valve needle 5. As an alternative to the embodiment depicted, valve seat surface 6 can also be formed on a separate valve seat member, which is received by valve seat support 1 and is joined to it.

On the other side of valve-closure member 7 facing away from the sealing seat, valve needle 5 has a cylindrical segment 8, on whose lateral surface one or more spiral-shaped swirl grooves 9 are provided. Swirl grooves 9 are enclosed in the radial direction by valve seat support 1, surrounding cylindrical segment 8, and they extend from a fuel chamber 10, which is a part of axial longitudinal bore hole 4 of valve seat support 1, to a dosing point 11 in the area of valve seat surface 6. Due to swirl grooves 9, a swirl flow is generated that promotes the turbulence and therefore the atomization of the fuel.

Fuel chamber 10 is bordered on the upstream side by a guide segment 12 and is connected via outlet openings 13 to an axial cavity 14, which penetrates the intake-side area of valve needle 5. At its end opposite valve-closure member 7, valve needle 5 is connected to an armature 15. Armature 15 cooperates with a solenoid coil 16 to close and open fuel injector 100. A coil shell 17, having steps in the radial direction, receives the winding of solenoid coil 16. Stepped coil shell 17 surrounds a core 18, that acts as the internal pole, and, in a step having a larger diameter, surrounds, at least partially axially, a non-magnetic intermediate part 19. Both armature 15 as well as core 18 and external valve housing 20 are made of a ferromagnetic material. A closed magnetic flux circuit is formed by core 18, armature 15, and valve housing 20, armature 15 being pulled in the direction of core 18 in response to the electrical excitation of solenoid coil 16. In this way, valve needle 5 is moved in opposition to the restoring force generated by a resetting spring 21, resulting in the opening of the fuel injector. Resetting spring 21, in this context, is supported on a support plate 25.

A supply cable 22 provides for the electrical power supply of solenoid coil 16 and is connected to valve housing 20 by a cable receptacle 23. In the opened state of fuel injector 100, armature 15, in an armature stop face 33, strikes against the end face of core 18 facing the spray-discharge direction 2.

Valve seat support 1 has a notch 40 in the form of a circumferential groove, into which valve housing 20 is crimped, as a result of which valve housing 20 is axially braced against valve seat support 1. Notch 40, in this context, is situated on the external periphery of valve seat support 1 in an area in which valve housing 20 contacts a lower end area. Valve seat support 1 has a further circumferential groove 41, into which a sealing ring 42 is inserted. Sealing ring 42 at a surface 43 formed on valve housing 20 is pressed into circumferential groove 41, to seal the interior of fuel injector 100 against the external space.

In order to adjust the lift of valve needle 5, a lift-adjustment disk 46 is provided between a stop surface 45 formed on a limit stop 44 and support plate 25, the axial insertion depth of valve seat support 1 into the valve housing 20 being set by lift-adjustment disk 46.

Core 18 of fuel injector 100 has a fuel feed pipe 50, in which an internal screw thread 51 is configured. Fuel is supplied via a fuel hose 52, which via a screw element 53 is screwed into internal screw thread 51 of fuel feed pipe 50. To seal the screw connection, a sealing element 54 is provided between screw element 53 and fuel feed pipe 50, the sealing element being made of a fuel-resistant material.

The crimping connection depicted in Figure 1 between the valve housing 20 and valve seat support 1 and alternative embodiments of the same are described on the basis of the following Figures.

Figure 2 in a cutaway representation depicts the segment designated in Figure 1 as II. To set a valve needle lift of valve needle 5, lift-adjustment disk 46 is introduced into valve housing 20. Lift-adjustment disk 46, in this context, contacts stop surface 45 of limit stop 44. Sealing ring 42 is introduced into circumferential groove 41 of valve seat support 1, the sealing ring in this exemplary embodiment having a cross-sectional surface adjusted to groove 41. Valve seat support 1 is inserted into valve housing 20, valve seat support 1 contacting stop surface 45 of limit stop 44 via support plate 25 and lift-adjustment disk 46. Valve housing 20 has a material bulge 70 located radially to the outside, which has an average axial distance  $d$  from circumferential notch 40 formed in valve seat support 1.

To form the crimping connection, an external surface 71 of material bulge 70 is impacted by

a suitable, e.g., tubular crimping tool, so that valve housing 20 is deformed in a plastic manner, and according to Figure 3, a projection 73, nose-shaped in cross-section, results in the area of an inner surface 72 of valve housing 20 formed over circumferential notch 40.

5 Nose-shaped projection 73, depicted in Figure 3, grips from behind a stop surface 74 of valve seat support 1, as a result of which a shifting of valve seat support 1 with respect to valve housing 20 is prevented.

10 As a result of average distance  $d$  of material bulge 70 with respect to circumferential notch 40, after the crimping of material bulge 70, the result is an axial bracing of valve housing 20 with respect to valve seat support 1, nose-shaped projection 73 pressing valve seat support 1 axially against stop surface 45 of limit stop 44. In addition, in the crimping connection according to the present invention, sealing ring 42 is impinged upon radially, which improves the seal between valve housing 20 and valve seat support 1.

In place of the circumferential groove, notches 40 that are configured in a different manner can also be provided, in order, e.g., to facilitate a detaching of the crimping connection. In accordance with the application case, support plate 25 can be omitted, or can be replaced by lift-adjustment disk 46.

In Figures 4 and 5, a further exemplary embodiment of the crimping connection according to the present invention is depicted. Elements already described are furnished with identical reference numerals, as a result of which there is no need for a repetitive description about these matters.

25 After valve seat support 1 is inserted into valve housing 20 to the insertion depth prescribed by stop surface 45 of limit stop 44, a spring element 61 is introduced into an interstitial space 60 formed between valve seat support 1 and valve housing 20. Interstitial space 60, in this context, is generated by a stepped exterior contour of valve seat support 1. Spring element 61 is preferably configured as a spring ring or as a disk spring. In addition, a support ring 62 is inserted into interstitial space 60 formed between valve seat support 1 and valve housing 20, spring element 61 being prestressed by support ring 62. The prestressing of spring element 61 is preferably accomplished by the influence of a tubular prestressing tool guided by valve seat

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support 1, the tool contacting support ring 62 at an annular surface 63, situated radially to the inside, of an end face 64 of support ring 62 facing away from spring element 61. In this manner, spring element 61 and support ring 62 are arranged as depicted in Figure 5.

To produce the crimping connection, a segment 65 of valve housing 20 on the side of the sealing seat is crimped in the direction of valve seat support 1, as a result of which the crimping connection is generated as depicted in Figure 5.

The crimping connection that arises is discussed in greater detail on the basis of Figure 5.

Spring element 61, via support ring 62, produces an axial tension between valve housing 20 and valve seat support 1. In this context, irrespective of the shape of crimped sealing-seat-side segment 65 of valve housing 20, spring element 61, as a result of support ring 62, is brought into contact with an end face 75, facing the spring element. In addition, if a support ring 62 is not used, the danger exists that in response to the crimping of sealing-seat-side segment 65 of valve housing 20, spring element 61 can be damaged or jammed.

In Figures 6, 7, and 8, a further exemplary embodiment of fuel injector 100 according to the present invention is depicted. In this context, Figures 6 and 7 each depict a partial axial cutaway view of the segment designated in Figure 1 as II. Figure 8 depicts the segment designated in Figure 7 as VIII.

In contrast to the exemplary embodiment described on the basis of Figures 4 and 5, sealing-seat-side segment 65 of valve seat 20 has a greater wall thickness. After the prestressing of spring element 61 by support ring 62, sealing-seat-side segment 65 is crimped in the radial direction using an appropriate prestressing tool. The resulting crimping connection can be produced uniformly over the entire circumference of sealing-seat-side segment 65 of valve housing 20, or, as in the depicted exemplary embodiment, it can have a plurality of crimping segments 66a through 66e, which, with respect to a valve axis 67, are arranged so as to be offset from each other circumferentially, valve housing 20 at crimping segments 66a through 66e being joined to valve seat support 1 in each case by a crimped partial connection, leaving out uncrimped segments 68a through 68d.

This type of crimping connection has the advantage that the stresses arising between crimping segments 66a through 66e are reduced by uncrimped segments 68a through 68d as compared to a circumferential crimping, and cracks are avoided in sealing-seat-side segment 65 of valve housing 20.

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The present invention is not limited to the exemplary embodiments described. In particular, fuel injector 100 can also be designed as a fuel injector 100 that opens to the outside. In addition, the described crimping connection between valve housing 20 and valve seat support 1 is also appropriate for other connections, in particular the connection between valve housing 2 and core 18. In addition, the described elements can also be arranged in a turned-away manner, in contrast to the depicted examples. In particular, spring element 61 can also be arranged on the side of stop surface 45, as a result of which spring element 61 can also be used in the embodiment described with respect to Figures 1 through 3.

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